Understanding the Relationships Between Lightning, Cloud Microphysics, and Airborne Radar-Derived Storm Structure During Hurricane Karl

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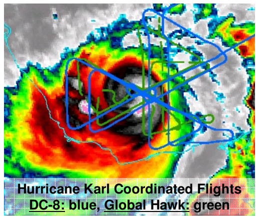
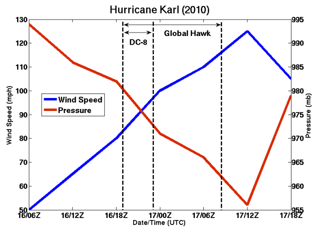
INTRODUCTION AND OBJECTIVES

The relationships between lightning, cloud microphysics, and tropical cyclone (TC) storm structure are being examined using data gathered from flights into rapidly intensifying Hurricane Karl (below) during NASA's Genesis and Rapid Intensification Processes (GRIP) experiment. The objective is to develop a better understanding of the microphysics within electrified and non-electrified regions of TCs. An improved understanding of the occurrence/absence of lightning in TCs may help us discover what information lightning data convey about the storm. This knowledge will be useful for real-time intensity forecast applications as well as future assimilation of lightning data into numerical models.


Hurricane Karl Coordinated Flights
DC-8: blue, Global Hawk: green



DATA COLLABORATION

GRIP data to be utilized in this project include:

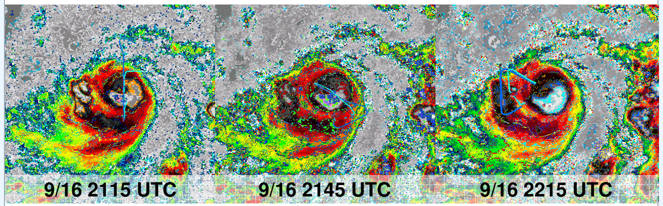
- Lightning Instrument Package (LIP) – Global Hawk
  - –Cloud-to-ground (CG) and intracloud (IC) lightning, as well as *in situ* electric field measurements
- Cloud Aerosol and Precipitation Spectrometer (CAPS) – DC-8
  - –Cloud droplet/particle concentrations (0.5 to 1600 microns), estimates of ice water content
- Airborne Precipitation Radar (APR-2) – DC-8
  - –Storm reflectivity, depolarization, and Doppler velocity can be used to determine rain rate, location of ice, and updraft velocity

Additional lightning datasets will be used to supplement the LIP:

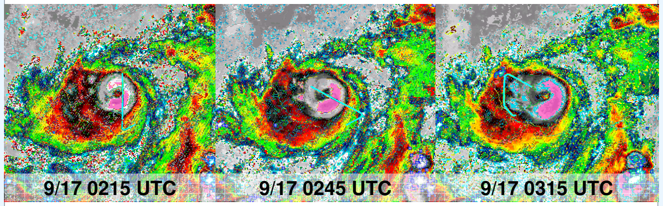
- Vaisala's Global Lightning Dataset (GLD360)
  - –CG lightning strikes
- World Wide Lightning Location Network (WWLLN)
  - –CG and strong IC lightning

KARL LIGHTNING ANALYSIS

Several inner core lightning bursts were detected by WWLLN and observed by GRIP aircraft during their flights into Karl (below).

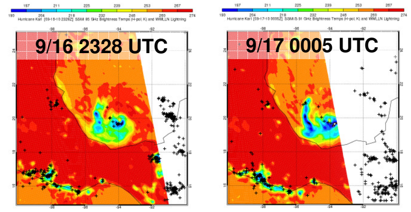


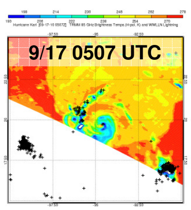
There also were extended periods with no inner core lightning and very limited overall lightning activity associated with Karl (below).



85/91 GHZ ICE SCATTERING SIGNATURES

Lightning in TCs is related to strong updrafts that support a deep layer of supercooled water and a mixed phase region where charge separation can occur (Black and Hallett 1999). Increased 85/91 GHz ice scattering (decreased brightness temperature, T_B) is associated with an increased probability of lightning (Cecil and Zipser 2002).

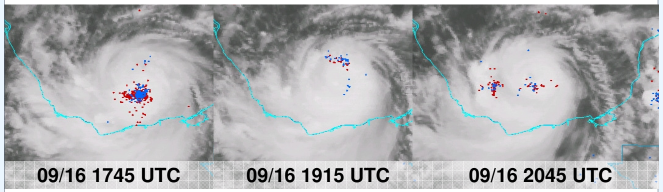




While the lightning often is co-located with colder T_B, the location of ice aloft does not fully explain the presence or absence of lightning within Karl. In some instances, no lightning occurs within the coldest T_B regions of the storm. Obviously, other storm parameters must be considered in order to better understand TC lightning.

WWLLN VS. GLD360 LIGHTNING

WWLLN and GLD360 are global lightning networks that can be used to study TCs in areas not covered by land-based networks like the National Lightning Detection Network (NLDN). Lightning from WWLLN (blue) and GLD360 (red) was visually compared to evaluate how well WWLLN samples the electrical structure of Karl.



The frequency and location of WWLLN-derived lightning match well with GLD360 lightning. This supports recent findings that WWLLN, despite its low detection efficiency, captures the convective structure of TCs quite well when compared to other networks (Abarca et al. 2011). Therefore, both WWLLN and GLD360 appear to be viable options for studying the convective structure and evolution of Karl.

FUTURE WORK

GRIP flights sampled Hurricane Karl during its rapid intensification in the southern Gulf of Mexico. The frequency and spatial distribution of lightning within Karl were highly variable during these flights. The next step will be to analyze the microphysical and radar data along both electrified and non-electrified flight segments. These data, combined with lightning datasets and *in situ* electrical measurements, will provide a better understanding of the storm properties relevant to lightning production in TCs.

REFERENCES

Abarca, S. F., K. L. Corbosiero, and D. Vollaro, 2011: The World Wide Lightning Location Network and Convective Activity in Tropical Cyclones. *Mon. Wea. Rev.,* **139**, 175-191.

Black, R. A., and J. Hallett, 1999: Electrification of the hurricane. *J. Atmos. Sci.,* **56,** 2004–2028.

Cecil, D. J., and E. J. Zipser, 2002: Reflectivity, ice scattering, and lightning characteristics of hurricane eyewalls and rainbands. Part II: Intercomparison of observations. *Mon. Wea. Rev.,* **130,** 785–801.